

## **Navigation for NEAR Shoemaker: the First Mission to Orbit an Asteroid**

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When the Near Earth Asteroid Rendezvous (NEAR) Shoemaker spacecraft began its orbit about the asteroid 433 Eros on February 14, 2000, it marked the beginning of many firsts for deep space navigation. Among these were the design and estimation techniques that were necessary to plan and execute an orbit about an irregularly shaped small body. Knowledge of the mass, gravity distribution, and spin state of Eros had to be quickly improved on final approach in order to predict the effect of trajectory correction maneuvers for capture and orbit control around Eros. This required the use of optical landmark tracking, which used pictures of craters on Eros as landmark information, in addition to the more traditional radio metric tracking from NASA's Deep Space Network. The operational use of optical landmark tracking was another navigation first for the NEAR mission. As part of the ongoing effort to improve the Eros physical model, altimeter data from the NEAR laser range instrument was also processed and analyzed. This paper describes the navigation strategy and results for the rendezvous and orbit phases of the NEAR mission. Included are descriptions of the new techniques developed to deal with navigation challenges encountered during the yearlong orbit phase. The orbit phase included circular orbits down to 35 km radius and elliptical orbits that targeted overflights to within 2.7 km above the surface. Many of these methods should prove useful for navigation of future missions to asteroids and comets.